

Chapter 4

Water Transmission System



***Installation of the
Tolt Transmission
Pipeline***

SPU's water transmission system consists of the large diameter pipelines, storage facilities, pump stations, and related infrastructure that convey raw water to the treatment facilities and treated water to the distribution systems of SPU's wholesale customers and its own retail service area. The water transmission system is part of the Transmission and Distribution business area. Proper management, operations, and maintenance of transmission system facilities ensures that SPU's wholesale and retail customers receive reliable and safe drinking water for consumption.

4.1 TRANSMISSION SYSTEM POLICIES

Management of the transmission system is guided by policies that SPU has developed. The first policy, the Transmission System Redundancy Policy, concerns SPU's process for making redundancy and retirement decisions for transmission system facilities and components. The second policy, the Access to Seattle Regional Water System Policy, concerns SPU's process for evaluating requests from other water purveyors to connect to SPU's transmission system.

4.1.1 Transmission System Redundancy Policy

Redundancy in the transmission system is one way that SPU can ensure reliability in delivering water to both its wholesale and retail service customers. While increased redundancy carries benefits of reduced or avoided customer outages, increasing transmission system redundancy adds capital and operation and maintenance (O&M) costs. Examples of redundancy include providing multiple ways of delivering water to a customer and having stand-by pumping capability or excessive water supply storage capacity. The purpose of this policy is to clearly establish the decision-making criteria that SPU uses for adding or retiring redundancy in the regional water transmission system.

SPU has not previously had a formal policy for transmission system redundancy. This policy was developed to incorporate asset management principles, primarily life-cycle benefit and cost analysis, into SPU's decision-making process regarding transmission system redundancy. This policy ensures that service reliability is considered along with costs when considering

retirement of existing, redundant facilities or adding new facilities to increase redundancy. This policy will ensure that SPU invests in redundant infrastructure only when it is cost-effective over the long-term.

Policy Statement

Consider redundancy in the transmission system on a case-by-case basis, with decisions based on an evaluation of net present value.

- 1. Consider retiring existing redundant facilities within the transmission system when they are at the end of their economic lives and the costs of a new replacement facility exceeds the avoided risks costs.*
- 2. Consider adding redundancy within the transmission system when replacing facilities within the transmission system that have reached the end of economic lives or when performing repairs on existing facilities within the transmission system that require wholesale customer outages and the costs of redundancy are less than the avoided risks costs.*
- 3. To increase redundancy, consider installing temporary or permanent looped systems, cross-over valves, intermediate line valves, and/or additional shut-off valves in the transmission system when the improvement provides positive net present value to the system.*
- 4. When evaluating net present value of options over the life of the project, include the capital costs of installing the redundancy improvement and all O&M costs, such as those to repair the new facilities. Also include the benefits of any avoided risk costs, such as the costs of wholesale customer outages.*

4.1.2 Access to Seattle Regional Water System Policy

Like other water purveyors within the Puget Sound region, SPU is continuously evaluating its water system operations and the availability of water resources to ensure that it can meet future and emergency water demands. SPU and other providers in the region (e.g., Tacoma Public Utilities and Everett Water Department) have been discussing the benefits of being able to move water between regional systems to areas where it is needed for customer use or for in-stream needs in rivers or creeks. While there are obvious benefits of connecting regional water systems, there are also

The Access to Seattle Water System Guidelines provide direction for reviewing requests to “wheel” water through the transmission system.

potential challenges in terms of potential drinking water quality and operational impacts.

In 2003, the Seattle Water Supply System Operating Board, whose membership includes representatives of Seattle and its wholesale customers, approved the *Access to Seattle Water System Guidelines* to provide guidance to SPU in reviewing another provider’s request for access or connection to SPU water transmission system facilities. In accordance with the guidelines, SPU has developed an internal policy to guide decisions regarding access to its transmission system.

The Access to Seattle Regional Water System Policy is new and was written to formalize the *Access to Seattle Water System Guidelines* (included as an appendix) adopted by the Operating Board. Prior to the development of this policy, SPU was adhering to the guidelines. Before the guidelines were created, the decisions regarding system access were made on a case-by-case basis. As of the date of this plan, SPU has not approved any such connection to SPU’s transmission system allowing water from another utility to be “wheeled” or moved through the Seattle regional water system.

Policy Statement

Evaluate requests for access to the Seattle regional water system using the Access to Seattle Water System Guidelines (Guidelines), based on the unique characteristics of the source that would be moved through the system.

1. *Consider options for full or partial access.*
2. *Weight drinking water quality and operational issues more heavily than other considerations.*
3. *Evaluate requests using asset management principles.*
4. *Update this policy as needed following any updates to the Guidelines by the Operating Board.*

4.2 SERVICE LEVELS

SPU has developed service levels that deal with the water service SPU provides to its wholesale customers. From a wholesale customer’s perspective, the quality of water service can be measured by the amount of water flow provided, the pressure of that water, and the duration of any water system outages. Many of

the drinking water quality service levels, as stated in the Water Quality and Treatment chapter, also apply to the transmission system. Table 4-1 summarizes SPU's service levels concerning service provision to wholesale customers.

Table 4-1. SPU's Service Levels for Managing Transmission System Assets

Service Level Objective	Service Level Target
Provide agreed-upon pressure and flow for wholesale customers.	Meet wholesale contract requirements for pressure and flow.
Limit drinking water supply outages.	Limit each unplanned outage in the transmission system to be within the maximum outage duration set for each pipe segment (24, 48 or 72 hours).

SPU is committed to meeting these service levels in its transmission system. Each of these service levels, including the rationale and current performance relative to the targets, are discussed below.

4.2.1 Pressure and Flow for Wholesale Customers

SPU's contracts with its wholesale customers provide that customers can expect a specified minimum pressure at each wholesale service connection. The newer wholesale service contracts also specify the maximum flow rate at the given pressure that would be provided for each service connection. By agreeing on these limits, both SPU and its wholesale customers can adequately plan and operate their respective systems to deliver the service they promise to their customers. The current transmission system is capable of providing the pressure and maximum flow rates called for in the wholesale contracts, and no incidents where SPU failed to meet its contract commitments have occurred in recent years.

4.2.2 Wholesale Outage Duration

SPU has established a service level specifying a target for the maximum duration of an outage for wholesale customers. This service level demonstrates SPU's commitment to providing reliable water delivery services with minimal interruptions. Prior to this *2007 Water System Plan*, SPU did not have an established service level for continuity of service to wholesale customers, and none is stated in the wholesale contracts.

The current transmission system is capable of providing the pressure and flow rates called for in the wholesale contracts, and no incidents where SPU failed to meet its contract commitments have occurred in recent years

There have been no outages to wholesale customers due to transmission pipeline failures since 1988

The water outage service level sets as a target a maximum duration of an outage for each transmission pipeline segment. SPU staff has conducted analysis of its transmission system components to determine the maximum amount of time it would take SPU crews to restore service to its wholesale customers in the event of an outage. The maximum outages range from 24 to 72 hours. A table with the maximum outage for each segment has been provided to the wholesale customers. The targets are based on site-specific conditions along each segment, such as the number of connections off of the segment, ease of access to the pipeline to make a repair, and type and size of pipe. To meet these targets, SPU will enhance its ability to make timely repairs to transmission pipelines by actions such as maintaining sufficient inventory of larger diameter pipe and fittings and standardizing and formalizing its response and repair procedures. Wholesale customers can use this information in planning and managing their distribution systems to prevent or reduce outages to their own customers.

There have been no outages to wholesale customers due to transmission pipeline failures since 1988.

4.3 EXISTING SYSTEM AND PRACTICES

SPU's transmission system consists of the facilities that convey bulk water to wholesale customers throughout the regional service area, as well as to SPU's own retail service area distribution system. SPU's transmission system facilities include the large-diameter transmission pipelines, storage facilities, pump stations, wholesale customer meters, and other appurtenances that are used in conveying water from SPU supply sources to its wholesale customers and the SPU retail service area.

Since the *2001 Water System Plan*, the configuration of the transmission system has been modified to accommodate the construction of the two new treatment facilities. Cedar River source water is now pumped from Lake Youngs to the new Cedar Treatment Facility with its 180-million gallons per day (mgd) treatment capacity. Treated water from the treatment facility's clear wells flows to the four Cedar River pipelines for transport to wholesale customers generally east and south of Lake Washington, and to SPU's retail service area. A maximum of 200 mgd of treated water can be transmitted from the Cedar Treatment Facility through the Cedar River pipelines.

Source water from the South Fork Tolt Reservoir now flows to the Tolt Treatment Facility instead of directly into the transmission system. After treatment, transmission pipelines supply water to retail customers in the north part of the direct service area and to wholesale customers generally east and north of Lake Washington. The Tolt transmission facilities are capable of hydraulically delivering 135 mgd through the treatment facility and downstream transmission pipelines; the treatment capacity is 120 mgd.

4.3.1 Existing Facilities

A transmission system facility is considered part of the regional or subregional system if it serves more than one water purveyor. SPU's wholesale contracts define these systems.

The regional and sub-regional water transmission systems include 189 miles of pipeline, two open reservoirs (West Seattle and Maple Leaf), five covered reservoirs, 15 pump stations, and six elevated tanks and standpipes. Taps off of the major supply transmission pipelines from the Cedar and Tolt sources deliver water to wholesale customer master meters and intertie locations. Wholesale customers operate their own distribution systems serving their own retail customers. Brief descriptions of the elements that comprise transmission system infrastructure are presented below, along with assessments of the condition of related assets. An inventory of the primary transmission system facilities is provided in the appendices.

Pipelines

Of the 189 miles of transmission pipeline leading from the supply reservoirs to the distribution system, approximately 29 miles of pipe are categorized as “raw water pipelines” that convey untreated water from the supply sources to the treatment facilities. These pipes vary in size from 24 to 96 inches in diameter and are made of either steel or concrete. The remaining approximately 160 miles of transmission pipe transport treated water from the treatment facilities to SPU’s wholesale and retail customers. These pipelines vary in size from 16 to 96 inches in diameter and are made of steel, concrete, or ductile iron.

SPU relies on the leakage history of its transmission pipes to provide an indication of condition. Leaks are identified by SPU crews that drive along the alignments of the transmission pipes weekly to look for water ponding on the surface. SPU’s annual leakage rates for steel and concrete pipes, which comprise most of the transmission system, are 7.7 and 6.9 leaks per 100 miles per year, respectively. This is well below the national average for U.S. utilities of 25 leaks per 100 miles per year.

In addition to system modifications to accommodate the two new treatment facilities, the following major improvements have been made to the transmission system since the *2001 Water System Plan* to increase redundancy and improve performance:

- Tolt pipeline (TPL) No. 2, Phases II and III, completed the second Tolt pipeline between Redmond and Snoqualmie Valley, generally following a route separate from Tolt pipeline No. 1.
- TPL No. 2 – Phase IV completed the second Tolt pipeline between TESS Junction and Lake Forest Park Reservoir, and TPL No. 1 along this stretch was placed in stand-by mode at reduced pressure.
- TPL No. 1 rehabilitation and replacement, Phase IIIB, replaced the portion of TPL No. 1 in the Snoqualmie Valley.
- Mercer Island 16-inch line seismic retrofit upgraded the pipeline to resist movement during an earthquake.
- Blow-off improvements upgraded various facilities used to drain large transmission lines for maintenance.
- Renton line valve improvements on Cedar River pipelines 1, 2, and 3 installed new valves south of Augusta gatehouse per SPU's agreement with the City of Renton to minimize damage should a pipeline failure occur.

Storage

SPU owns, operates, and maintains 15 storage facilities in its transmission system. All store treated water. An assessment of the condition of these facilities is described below.

Reservoirs. Five of SPU's transmission system reservoirs are covered, and two are open reservoirs. Four of the five covered reservoirs (Eastside, Riverton Heights, Soos North, and Soos South) are prestressed or reinforced concrete tanks constructed between 1979 and 1990. Lake Forest Park Reservoir was constructed in 1961-62, and its structure consists of a hypalon-lined, reinforced concrete slab with a floating cover that was added in 2003. The structure of the two open reservoirs, Maple Leaf and West Seattle, consists of hypalon-lined, unreinforced concrete slabs. These reservoirs were constructed in 1910 and 1932, respectively. As described in Chapter 3, Water Quality and

Inspections revealed that the storage reservoirs are in good condition.

Treatment, these reservoirs are slated to be replaced with new, reinforced concrete, underground reservoirs.

The condition of the reservoirs is typically assessed by inspecting the structures, the embankment stability, the valves and piping, and any internal lining, and measuring the leakage rate from the reservoirs. SPU performs routine structural inspections of the tanks during cleaning activities to assess their condition and ensure that they meet regulatory requirements. Minor and major deficiencies are addressed through capital programs when they are identified.

Inspections revealed that the storage reservoirs are in good condition. The internal lining of Lake Forest Park Reservoir was installed during its covering in 2003. The leakage rates from Maple Leaf, West Seattle, Soos North, and Soos South Reservoirs are low, under 0.12 gallons per minute per million gallons (gpm/MG). The leakage rates for Lake Forest Park and Eastside Reservoirs are 1.0 and 1.9 gpm/MG, respectively. Leakage tests were performed for these six reservoirs during 2003-2004, prior to the installation of the lining in Lake Forest Park Reservoir. In 2006, Eastside Reservoir underwent repairs to reduce its leakage rate.

Standpipes and Elevated Tanks. The SPU water transmission system includes five elevated tanks, one standpipe, and two control works surge tanks to provide drinking water storage. The elevated tanks and standpipes were constructed between 1925 and 1959. They range in capacity from 0.34 to 2 mg.

Tanks, including standpipes, are expected to have a service life of approximately 100 years with continued maintenance. SPU inspects the tanks visually to evaluate their condition and appearance. The condition of the tanks is evaluated based on the interior and exterior coatings, cathodic protection, valves and pipes, and the seismic upgrade status. The condition of each tank varies, depending on its year of construction and the year the last interior and exterior coatings were applied. Since there are some tanks that have not yet had seismic upgrades performed, and many tanks are nearing their next painting cycle, SPU has the following programs in place to improve their condition.

- **Seismic Upgrade Program.** The objective of the seismic upgrade program is to develop cost-effective mitigation solutions that protect SPU customers from loss of service and property damage following an earthquake. The program will

include both physical hardening and non-hardening recommendations for various water facilities, including reservoirs, tanks, and standpipes.

- **Tank and Standpipe Recoating.** The tank recoating program involves safety modifications at tank sites, minor structural repairs, and interior and exterior surface preparation and coating following a regular maintenance cycle. The program includes nine standpipes and eight elevated tanks, some of which are part of SPU's distribution system. Some other tanks in the SPU water system will require some maintenance as well. Tank painting generally follows an approximate 15-year cycle. The timing will vary with need as shown by inspections and economic analysis.

SPU upgraded five of the elevated tanks (Richmond Highlands No. 1 and No. 2, Magnolia Tank, and Control Works NE and SW tanks) in 1993-1994. Myrtle No. 1 and No. 2 elevated tanks were upgraded in 2003. Beverly Park tank and Foy standpipe have not been upgraded yet. The net present value of upgrading both of these facilities will be assessed, and both facilities will be upgraded if deemed appropriate according to net present value analysis.

Pump Stations

SPU operates 15 transmission system pump stations. These pump stations are inspected regularly and equipment is repaired or replaced as needed. The only significant modification to the pump stations is occurring through the SCADA Valve Upgrade Project, in which SPU is installing position indicators for remote control valves in all of its pump stations. Aside from minor reconfigurations and component replacements/upgrades, there have been few changes to existing pump stations since the *2001 Water System Plan*.

The condition of SPU's pump stations varies depending on the age and condition of their components, their usage, past maintenance or rehabilitation activities, and other factors. SPU currently does not have a formal, structured process for deciding when an asset or component in a water pump station should be replaced or upgraded. Current practices determine replacement/upgrade schedules according to the expertise and opinion of SPU Field Operations Division staff. Pumps are monitored for efficiency and overhauled every 5 to 7 years.

Transmission system operations have been modified to accommodate the addition of the two new treatment facilities and new transmission system pipelines.

4.3.2 Operations

Transmission system operations have been modified to accommodate the addition of the two new treatment facilities and new transmission system pipelines. Prior to 2004, water was diverted from the Cedar River at Landsburg into Lake Youngs through two supply lines. Water leaving Lake Youngs flowed by gravity through the Lake Youngs tunnel to the Control Works, where it was divided and sent into four major transmission lines. Two bypass pipelines allowed water to be diverted from Landsburg directly into the transmission system, bypassing Lake Youngs. Lake Youngs Bypass 5 connected the supply lines to the Lake Youngs tunnel, bypassing just the lake. Bypass 4 connected the supply lines to the transmission system at the Control Works, bypassing not only the lake but the outlet tunnel as well. Finally, the Lake Youngs pump station pumped water out of the tunnel to supply Soos Reservoirs and two local water districts.

When the Cedar Treatment Facility was built, most of the original bypass pipelines were converted to other uses. The upstream segments connected to the supply lines were left intact, retaining the ability to bypass Lake Youngs. The center segments were connected to the ozonation facility and serve as ozone contact chambers. The downstream segments of the bypass lines were connected to the clear wells, and now deliver finished water to Control Works.

The new clear wells raised the hydraulic gradient upstream of the Control Works by 24 feet. In order to prevent overflow at the surge tanks at Control Works, new flow control valves were installed on both finished water pipelines. The Lake Youngs pump station was relocated to one of the new flow control facilities.

Currently, water is pumped from Lake Youngs into the treatment facility and flows through the treatment processes by gravity to the clearwells. From the clearwells, flow to Control Works is through two finished water pipelines (FWP) and flow control facilities (FCF). FWP No. 4 and FCF No. 4 deliver water directly to Control Works through the old bypass 4 pipeline. FWP No. 5 and FCF No. 5 deliver water to the Lake Youngs tunnel through the old bypass 5 pipeline.

4.3.3 Maintenance

Proper maintenance of SPU's transmission system components ensures that SPU will be able to deliver reliable water service,

reduce the risk of unexpected failures, and provide safe drinking water quality to its wholesale and retail customers. SPU has prepared a number of strategic asset management plans (SAMPs) for each major class of transmission system infrastructure components. The SAMPs outline maintenance strategies for each asset. Summaries of those maintenance strategies are provided in this section.

Pipelines

Maintenance activities for water transmission pipelines include cleaning of exposed pipes and periodic inspections of pipelines. Moss and dirt are cleaned from exposed transmission pipes at least once every three years. Internal inspections are performed when pipes are emptied and out of service for repairs or maintenance, allowing inspectors to enter the pipe. External inspections are performed only when opportunities present themselves, such as when a pipeline is exposed for other work. An exception to this is the recent external inspections of the single line segment of the original Tolt pipeline No. 1 between the treatment facility and Kelly Road, and Cedar River pipeline No. 4. The purpose of these external inspections was to confirm that the concrete cylinder pipelines had not undergone significant deterioration since 1991, the date of the last inspections of concrete cylinder pipeline in SPU's transmission system.

Reservoirs and Tanks

Storage facility cleaning is performed to remove sediment, debris, and/or microbial growth. Cleaning is done on a scheduled basis or when water quality inside the storage has declined. The cleaning schedule is explained in the Water Quality and Treatment chapter.

Water Pump Stations

Maintenance activities at water pump stations ensure that the stations continue to operate with minimal failure, thereby reducing the likelihood of customer outage, loss of pressure, and potential introduction of pathogens into the distribution systems. SPU performs three types of maintenance activities for its pump stations as described below.

Preventative Maintenance. Preventative maintenance is maintenance which is carried out on a routine basis on elapsed time schedules or equipment run-time hours. Preventative maintenance is designed to eliminate routine failures. Table 4-2

lists typical preventive maintenance activities, the craft responsible for performing them, and the normal frequency at which those activities are performed.

Table 4-2. Typical Pump Station Maintenance Activities

Craft	Task	Approximate Frequency
Carpenter	Building inspection	Annually
Electrician	Generator exercising	Monthly
Electrician	Pump motor starter maintenance	Every 6 mos
Electrician	Pump motor starter maintenance	Annually
Electrician	Valve operator	Annually
Mechanics	Overhaul pressure regulator	2 to 5 yrs
Mechanics	Flow meter inspect/overhaul	2 to 5 yrs
Mechanics	Diesel engine exercising	Every 2 mos
Mechanics	HVAC filter change	Every 2 to 3 mos
Mechanics	Air conditioner inspection	Annually
Mechanics	Pump station check	Twice weekly
Grounds	Basic site check	Weekly

Corrective Maintenance. When preventative maintenance tasks or other data indicate minor equipment malfunctions, corrective maintenance is performed. This type of equipment malfunction does not restrict normal operation of the pump station.

Emergency/Reactive Maintenance. Emergency maintenance is generally carried out when a piece of equipment has failed and the need to restore its performance is critical. The criticality of each pump has been predetermined and incorporated into SPU's computerized work management system to ensure that repair of these facilities receives higher priority than other, non-critical repairs and that critical facilities are quickly put back into service.

Wholesale Customer Meters

SPU owns and maintains 126 wholesale water meters at intertie locations with wholesale customer systems that measure usage and provide a basis for billing wholesale customers. The most significant change to SPU's wholesale meters since the *2001 Water System Plan* has been the installation of radio frequency modules on almost all of the wholesale meter registers, which allow safer and faster meter reading by enabling the meters to be

read without requiring personnel to enter the meter chamber. Meter installations that raise safety concerns, cannot be tested on site, or have older meters that are difficult to maintain are being replaced.

Wholesale customer meters are tested annually and maintained to meet accuracy standards.

Wholesale customer meters are 3 to 24 inches in diameter and classified as “large meters.” SPU’s policy is to install, test, and maintain all customer service water meters in such a way as to meet the accuracy standards of the American Water Works Association (AWWA). SPU’s meter testing and maintenance practices are described below.

Meter Testing. Testing is performed annually on wholesale customer meters. SPU’s meter testing practices include meeting standards of performance AWWA C700, C701, C702, C703; bench-testing all new large meters prior to installation to verify accuracy of meter lots; bench-testing all rebuilt internal assemblies; and field testing all new, exchanged, and repaired large meters.

Meter Maintenance. SPU performs scheduled maintenance activities on large meters based on a variety of criteria including manufacturer recommendations, AWWA standards and consumption history. Unscheduled maintenance activities are performed in response to billing questions and customer requests.

4.4 NEEDS, GAPS, AND ISSUES

SPU has completed a number of improvements to its transmission system since the *2001 Water System Plan* to improve transmission system reliability. In its continued effort to improve the quality of its services, SPU has identified several needs, gaps, and issues in regards to the transmission system. Needs include maintaining high water quality in the transmission lines, developing a strategy for maintaining, repairing, rehabilitating, and/or replacing transmission system pipelines, and enhancing transfer capabilities between the Cedar and Tolt supply sources. The following subsections summarize these issues and SPU’s approach to addressing them.

4.4.1 Water Quality Issues in the Transmission System

Two water quality issues directly related to the transmission system include water quality in cement mortar-lined pipelines and covering the open tanks at the control works.

Water Quality in Transmission Lines

Large-diameter transmission pipelines composed of metal (e.g., steel, ductile iron, cast iron) are often lined with cement mortar to prevent corrosion and deterioration of the metal pipe wall. Lining transmission pipelines is a well-established practice nationwide; the benefits of which include increased pipe longevity, reduced risk of a pipeline failure, and consistent hydraulic performance. Ultimately, the practice of lining transmission pipelines provides SPU and its customers with cost-savings over the life of the transmission pipes. There are, however, water quality impacts of applying cement mortar lining to the interior of pipes.

Cement lining of pipelines can cause the pH in the water to increase.

Cement lining of pipelines can cause the pH in the water to increase (i.e. the water to become more alkaline or basic) when a section of pipeline is taken out of service for repair or maintenance but kept full of water. During extended contact between the water and the cement, calcium compounds can leech out of the cement and raise the pH of the water. Although pH is typically not a health issue until it becomes extremely low or very high, customers may find that water with moderately elevated pH tastes or feels different than that to which they are accustomed. Additional customer concerns could include loss of aquarium fish, poor rinsing at car washes, or adverse impacts on other commercial and industrial facilities. Higher pH waters can impact other water quality parameters, such as increased formation of trihalomethanes and decreased effectiveness for chlorine disinfection.

The EPA-recommended lower and upper values for pH are 6.5 and 8.5, respectively. For the situations where water in transmission lines exhibits elevated pH, SPU establishes the following guidance:

- Water with pH up to 9.5 can be sent to the distribution system.
- If water in the pipeline has pH above 9.5, the pipeline will be flushed.
- In emergency circumstances, the SPU's Director may allow the pH 9.5 limit to be exceeded.

If future experience shows that the upper pH limit of 9.5 is inappropriate, this guideline will be revised.

Control Works Tank Covering

A separate, but water quality-related issue, is the lack of covers over the twin surge tanks at the Control Works. The openings are approximately 44 feet above ground level but contain treated water that is exposed to the open air. Options for covering the tanks are being investigated.

4.4.2 Pipeline Repair and Replacement

SPU's transmission system consists primarily of two types of pipe, distinguished by their material and their distinct modes of failure:

- Concrete cylinder pipe can have sudden, unexpected, and oftentimes very destructive failures.
- Steel and ductile iron pipelines usually develop increasing numbers of leaks that are detectable well before catastrophic failure.

Failure issues associated with each type of pipeline differ because their different failure modes and risks. The following section describes the failure issues for both types of pipes.

Concrete Cylinder Pipe

Concrete cylinder pipe (CCP) is manufactured by lining the interior of a thin-walled, steel cylinder with concrete mortar, then wrapping the exterior of the steel cylinder with steel reinforcing rod under tension. The entire exterior is then coated with concrete mortar to provide additional stiffness and corrosion protection. CCP derives most of its strength from the combined strength of the steel cylinder and the pretensioned rod reinforcing.

During the past several decades, CCP has received national attention from water professionals because of some sudden, unexpected, and often quite destructive failures. Unlike steel pipes, which typically exhibit leaks as they begin to fail, CCP failures are more often catastrophic in nature. CCP failures usually result from corrosion of the tensioned reinforcing rods. The steel cylinder itself lacks sufficient strength to withstand the pressure of the water inside the pipe. Should the tensioning rods corrode or deteriorate to the point where they no longer provide sufficient tension to hold the pipe together, the pipe cylinder can fail, sometimes producing explosive bursts of water.

Cathodic protection is a method employed to minimize the rate of electrochemical corrosion of metallic materials, such as pipes.

SPU's only sudden CCP failure occurred in 1987 on the Tolt Pipeline No. 1 (TPL1). The failure caused significant flooding and property damage. Detailed investigations revealed that the failure was caused by a particular type of corrosion known as hydrogen embrittlement, where chemical reactions with hydrogen ions in the soil cause the steel to turn brittle and lose its strength. The chemical process is irreversible, and the only remedy is to replace the pipe or to use it as a casing and to install new, smaller-diameter, fully competent pipe inside. Only the steel that was used for the spiral wrap by one particular pipe manufacturer (United Pipe) was found to be susceptible to hydrogen embrittlement. In SPU's system, all pipe made by United and prone to hydrogen embrittlement has been either replaced or slip-lined with new steel or ductile iron pipe.

Investigations in the early 1990s revealed some deterioration of the rest of the CCP lines; however, no CCP failures have been experienced since the 1987 failure. The absence of additional CCP failures and condition assessment reports invariably lead to the conclusion that SPU's remaining CCP are in a somewhat deteriorated but still serviceable condition. In an effort to mitigate further deterioration of CCP, SPU piloted a cathodic protection project. Cathodic protection has the effect of reducing the rate of metal corrosion in pipelines. The pilot installation proved successful and showed that a single deep cathodic protection well can protect about one mile of concrete cylinder pipe with fairly even electric potential distribution. The pilot project indicates that the risk of CCP failures can be well-mitigated by cathodic protection efforts.

In the *2001 Water System Plan*, SPU had conservatively planned to replace all of its CCP with steel pipelines in its 25-year Capital Facilities Plan. In light of SPU's completed replacement of all hydrogen-embrittlement prone CCP, condition assessments, and cathodic protection pilot study, SPU no longer believes pro-active replacement, or even slip-lining, of all its CCP to be necessary. Rather, SPU's new, long-term strategy for managing CCP is as follows:

- Maximize the use of cathodic protection to extend the service life of CCP well into the future and continuously assess its effectiveness in arresting corrosion.
- Maintain and enhance SPU's capability to identify pipe failures with pressure sensing and isolate them quickly so as to

minimize property and environmental damage arising from the uncontrolled release of water.

- In the unlikely event that a failure does occur, plans are in place to respond expeditiously and repair the pipe and place it back on line, as provided in the outage service levels.
- Stay current on new pipeline inspection technologies. When high tech tools and methods for non-destructive, no-dig condition assessment for this particular type of concrete cylinder become available, they could be used to inspect pipe sections. After such inspections, SPU can apply asset management principles to decide if any should be replaced.

Steel and Ductile Iron Pipe

Steel and ductile iron pipelines differ significantly from CCP in that they develop increasing numbers of leaks well before catastrophic failure. In most cases, leaks can be repaired without depressurizing or taking the pipeline out of service. An aging steel pipeline is more likely to present an economic concern due to its increasing repair costs well before its structural strength is imperiled.

When the incidence of leaks on a steel pipeline starts to increase, installing cathodic protection can stop further increases. SPU has used cathodic protection, coupled with internal cement mortar relining, on numerous sections of steel pipelines where either significant leaks have been experienced in the past or may be expected in the future due to corrosive soils. At this time, SPU experiences a very low leak rate on its steel pipelines.

In the *2001 Water System Plan*, in light of the Tolt pipeline failure event in 1987, the 25-year Capital Facilities Plan assumed replacement of major portions of the older steel pipelines would be required. No specific locations were identified, although significant funding per year for more than a decade was included in the Capital Facilities Plan. The very low level of leaks currently experienced, the minimal damage produced by these leaks, the success of the cathodic protection program, and the fact that, in most cases, steel pipelines can be repaired while remaining in service all suggest that massive replacement of steel pipelines over the next 30 years is not necessary. Cathodic protection is a viable alternative to replacement along higher risk areas, like steep slopes or near critical utilities and transportation corridors where an

undetected leak may result in high damage costs and where replacement costs are high.

4.4.3 Cedar/Tolt Transfer Improvements

During normal operations, SPU's two major supply sources, the Cedar River and the South Fork Tolt River, each supply portions of SPU's service area. The Cedar generally provides water to the southern and central portions, and the Tolt generally provides water to the northern portions of the service area. During emergency or unusual circumstances, it may become necessary to use one source of supply to provide water to areas of the system to which it would not normally provide water. These circumstances could include water quality or source water production problems at one supply source, increased demand in one portion of the system, or greater need for operational efficiency during critical periods.

Cedar/Tolt transfer improvements study will evaluate options to increase flexibility of using water from each source.

In an effort to maximize the reliability and flexibility of the transmission system, SPU is investigating opportunities to improve transmission and SCADA infrastructure as well as operations to facilitate more reliable transfer of Cedar source water to the northern portions of the regional system, and Tolt source water into additional southern portions of the service area. The goals of this study are to improve understanding through analysis and/or testing of actual and perceived system/operational boundaries and constraints; understand clearly the costs, risks and service level implications of pushing boundaries, where appropriate; and recommend the best use of SPU supply and transmission assets to avoid, manage or mitigate unusual and emergency conditions at the lowest life-cycle cost.

4.5 IMPLEMENTATION/ACTION PLAN

As described earlier, the primary issues facing the transmission system include water quality issues from concrete mortar linings in new transmission piping and having uncovered tanks at the Control Works, replacement and/or rehabilitation of aged steel and concrete cylinder pipe, and enhancement of the transfer capabilities for the Cedar and Tolt supply sources. To address those and other issues discussed in this chapter, SPU has identified the following major implementation and action plan items:

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- Maintain and operate the transmission system to meet the pressure and flow service level targets and pH guidelines.
- Complete preliminary engineering, design, and construction of covers for the Control Works surge tanks.
- Continue to implement cost-effective cathodic protection projects for the CCP and steel transmission pipelines to extend their service lives well into the future; continuously monitor the effectiveness of cathodic protection in arresting corrosion; and stay abreast of new technologies for non-destructive, no-dig condition assessment for CCP.
- Enhance SPU's transmission pipeline repair capability and manage outage durations in the transmission system pipelines to meet service level targets.
- Complete the Cedar/Tolt transfer improvements study and implement improvements with positive net present value to allow greater flexibility in using water from each source.

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